Notice No.6

Rules and Regulations for the Classification of Naval Ships, January 2021

The status of this Rule set is amended as shown and is now to be read in conjunction with this and prior Notices. Any corrigenda included in the Notice are effective immediately.

Please note that corrigenda amends to paragraphs, Tables and Figures are not shown in their entirety.

Issue date: November 2021

Amendments to	Effective date	IACS/IMO implementation (if applicable)
Volume 2, Part 1, Chapter 3, Section 21	1 January 2022	N/A
Volume 2, Part 2, Chapter 1, Section 4	1 January 2022	N/A
Volume 2, Part 7, Chapter 1, Sections 4 & 5	1 January 2022	N/A
Volume 2, Part 7, Chapter 3, Section 4	1 January 2022	N/A
Volume 2, Part 7, Chapter 5, Section 11	1 January 2022	N/A
Volume 2, Part 9, Chapter 1, Sections 1 & 2	1 January 2022	N/A
Volume 2, Part 9, Chapter 3, Section 5	1 January 2022	N/A
Volume 2, Part 9, Chapter 8, Section 5	1 January 2022	N/A
Volume 2, Part 12, Chapter 1, Section 10	1 January 2022	1 January 2022

Lloyd's Register

Volume 2, Part 1,
Chapter 3
Requirements for Design, Construction, Installation and Sea Trials of Engineering Systems

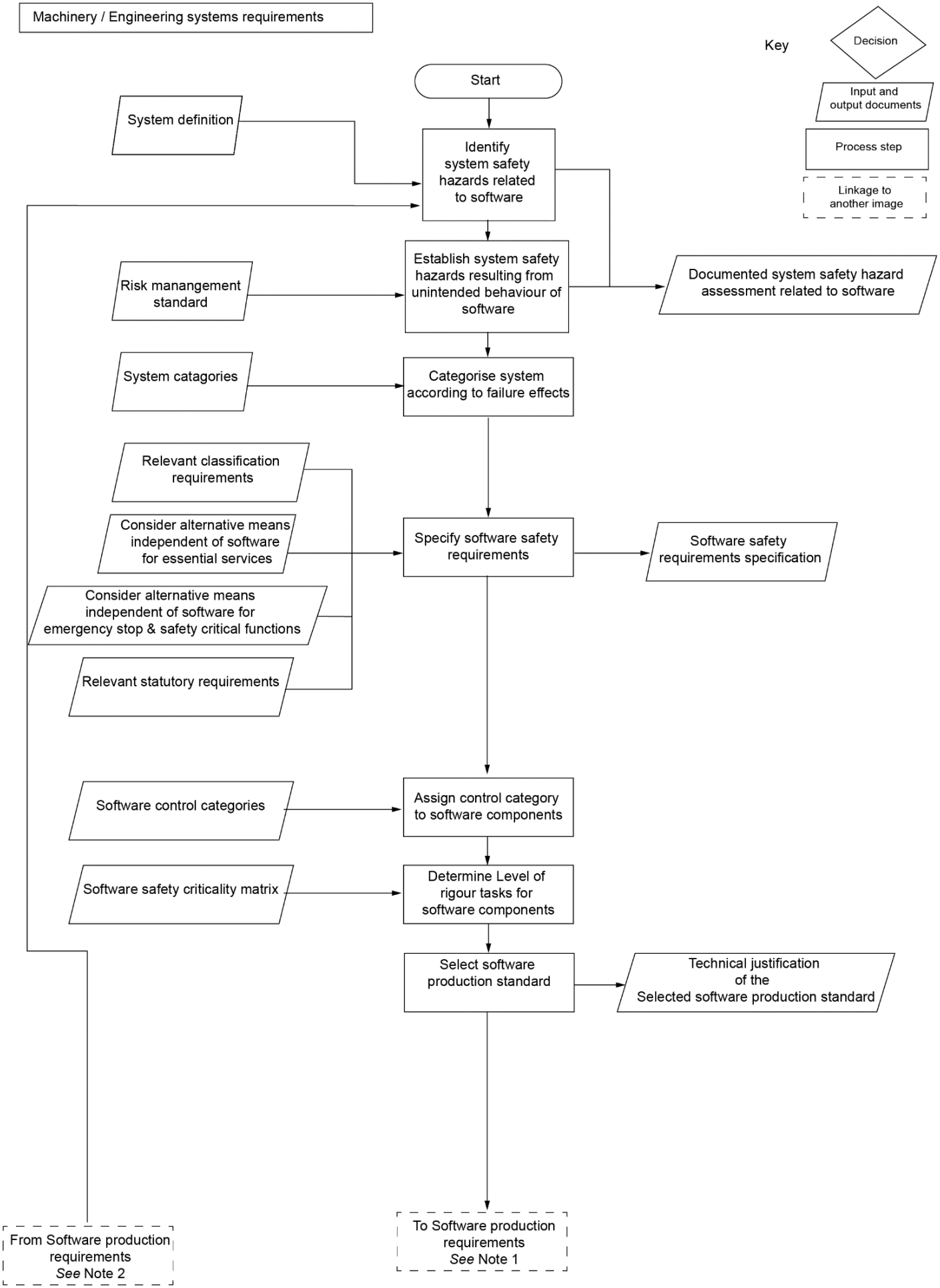
■ *Section 21*
Software in systems, machinery and equipment

21.1 Goal, functional requirements and applicability

21.1.1 Goal: The use of software in systems, machinery and equipment is not to compromise the functionality or safety of those systems, machinery and equipment.

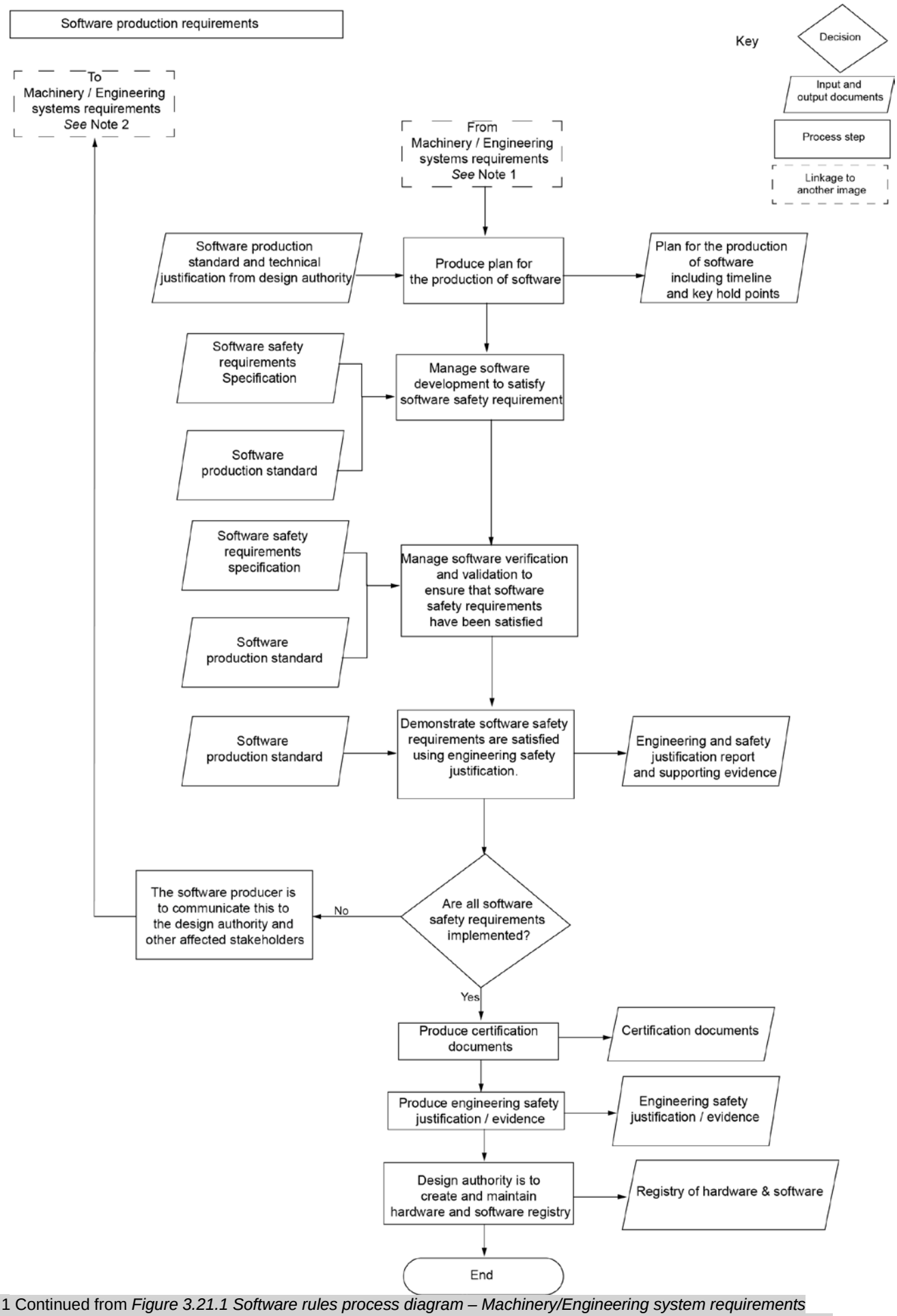
21.1.2 Functional requirements: The safety risk arising from the use of software in systems, machinery and equipment is to be appropriately managed by ensuring that software safety requirements are identified and satisfied. A diagrammatic view of the software rules process is shown in *Figure 3.21.1 Software rules process diagram – Machinery/Engineering system requirements* and *Figure 3.21.2 Software rules process diagram – Software production requirements*.

21.1.3 Applicability: These rules apply to all systems, machinery and equipment mentioned in the remaining Parts of *Vol 2 Machinery and Engineering Systems* of these Rules where software is used as an implementation technology. They also apply to software where the software is used in a role that has an identified impact upon the safety of the ship. Instances where the operational performance of the software can only be characterised accurately in probabilistic terms, e.g. Machine Learning or Artificial Intelligence based systems, will require further and more extensive consideration beyond the scope of this set of Rules. *See also Vol 2, Pt 9, Ch 8, 5.6 Programmable electronic systems – Additional requirements for the production of software*.



Note 1 *See* continuation in *Figure 3.21.2 Software rules process diagram – Software Production Requirements*
Note 2 Continued from *Figure 3.21.2 Software rules process diagram – Software production requirements*

Figure 3.21.1 Software rules process diagram – Machinery/Engineering system requirements



Note 1 Continued from *Figure 3.21.1 Software rules process diagram – Machinery/Engineering system requirements*
Note 2 *See* continuation in *Figure 3.21.1 Software rules process diagram – Machinery/Engineering system requirements*

Figure 3.21.2 Software rules process diagram – Software production requirements

21.2 Definitions

21.2.1 Software: Intellectual creation comprising the programs, procedures, data, rules and any associated documentation relating to the operation of a data processing system or complex hardware, where complex hardware includes but is not limited to custom micro-coded components including application specific integrated circuits (ASIC), programmable logic devices (PLD), field programmable gate arrays (FPGA) or similar electronic technologies.

21.2.2 Software module: A standalone executable element of code that provides specific and closely coupled functionality.

21.2.3 System Design Authority: Person or organisation that is responsible for the design of the system. In this context, the single designated party responsible for system functionality in its entirety at each lifecycle stage, from concept to disposal.

21.2.4 Software producer: The organisation responsible for producing and/or maintaining the software module.

21.2.5 System safety hazards: The hazards to the safe operation of the ship resulting from failure or unintended behaviour of a system, item of machinery or equipment which incorporates software.

21.2.6 Software safety requirements: Requirements placed on the software which define what the software must do and what the software must not do to address system safety hazards including the degree of reliance placed upon the software.

21.2.7 Level of rigour task: A specification of the depth and breadth of software analysis and verification activities necessary to provide a sufficient level of confidence that a software module will function as required.

21.2.8 Software Production Standard: An International or National Standard to be applied to the production of software

21.3 Performance requirements

21.3.1 The System Design Authority is to identify and document the system safety hazards related to software, categorise the system, and assign the software control categories to each software module. It is then to identify the resulting level of rigour tasks to be applied to each software module utilising processes identified in this Section of these Rules, or an equivalent process acceptable to LR. The resulting software safety requirements and any safety-related statutory and classification software requirements are to be documented and provided to the software producer.

21.3.2 Software safety requirements are to be derived from the identified system safety hazards and their categorisations. Consideration is to be given to the effects of failure of a software module or unintended behaviour of a software module which could credibly

(a) result in a system safety hazard;
(b) impair the mitigation of a system safety hazard; or
(c) impair recovery after a system safety hazard has occurred.

The traceability between software safety requirements and system safety hazards is to be documented as part of this process. The establishment of a Systems Risk Register is to be considered to assist the identification of system safety hazards and tracing the resulting software safety requirements. Where the risk assessment technique required by *Vol 2, Pt 1, Ch 3, 21.3.3 Performance requirements* requires the creation of a Systems Risk Register, this is to be submitted for information.

21.3.3 System safety hazards resulting from failure or unintended behaviour of software in systems, machinery or equipment incorporating software modules are to be established in accordance with IEC/ISO 31010 *Risk Management – Risk Assessment techniques* and/or an appropriate standard acceptable to LR.

21.3.4 Where two systems or items of machinery are intended to function as redundant components, the risk of the software introducing common mode failures that result in the loss or unintended behaviour of both components is to be considered as part of the hazard assessment.

21.3.5 System safety hazards are to be identified and the system categorised in accordance with the failure effects in *Table 3.21.1 System categories* or an equivalent categorisation acceptable to LR.

Table 3.21.1 System categories

Category	Effects	Typical System Functionality
I	Those systems, failure of which will not lead to unsafe conditions for human safety, safety of the ship and/or threat to the environment.	Monitoring function for informational or administrative tasks
II	Those systems, failure of which could eventually lead to unsafe conditions for human safety, safety of the ship and/or threat to the environment.	Alert and monitoring functions Control functions which are necessary to maintain the ship in its normal operational and habitable conditions
III	Those systems, failure of which could immediately lead to unsafe conditions for human safety, safety of the ship and/or threat to the environment.	Control functions for maintaining the vessel's propulsion and steering Protection and safety functions
IV	Those systems, failure of which would usually result in loss of the ship, death, and/or irreversible significant environmental impact.	Control systems for which manual intervention to avert danger in the event of failure or malfunction is not possible

21.3.6 Software modules are to be assigned a software control category in accordance with the module's degree of control over the system hardware, sub-systems or components as given in *Table 3.21.2 Software control categories* or an equivalent categorisation acceptable to LR.

Table 3.21.2 Software control categories

Software Control Category	Name	Description
1	Full Control Authority	Software module that exercises autonomous control authority over potentially safety-significant hardware systems, sub-systems or components without the possibility of predetermined safe detection and intervention by a control entity to preclude the occurrence of a hazard.
2	Supported Control Authority	Software module that exercises control authority over potentially safety-significant hardware systems, sub-systems or components, allowing time for predetermined safe detection and intervention by independent safety mechanisms to mitigate or control the hazard.
		Software module that displays information requiring immediate Operator intervention to execute a predetermined action for mitigation of or control over a hazard. Software exception, failure, fault or delay will allow, or fail to prevent, hazard occurrence.
3	Shared Control Authority	Software module that issues commands over safety-significant hardware systems, sub-systems or components requiring a control entity to complete the command function. The system detection and functional reaction includes redundant, independent fault tolerant mechanisms for each defined hazardous condition.
		Software module that generates information used to make critical decisions. The system includes several redundant, independent fault tolerant mechanisms for each hazardous condition, detection and display.
4	Influential	Software module that generates information used to make decisions by the Operator but does not require Operator action to avoid a hazard.

21.3.7 The Level of rigour tasks to be applied to each software module during production are to be determined in accordance with the Software safety criticality Matrix in *Table 3.21.3 Software safety criticality matrix* or an equivalent categorisation acceptable to LR.

Table 3.21.3 Software safety criticality matrix

	System Category			
Software Control Category	I	II	III	IV
4	SwCI 1	SwCI 1	SwCI 1	SwCI 3
3	SwCI 1	SwCI 1	SwCI 2	SwCI 3
2	SwCI 1	SwCI 2	SwCI 3	SwCI 4
1	SwCI 1	SwCI 2	SwCI 4	SwCI 4
	Level of rigour tasks			
SwCI 1	Safety-specific testing.			
SwCI 2	Analysis of requirements and architecture; and conduct in-depth safety-specific testing.			
SwCI 3	Analysis of requirements, architecture and design; and conduct in-depth safety-specific testing.			
SwCI 4	Analysis of requirements, architecture, design and code; and conduct in-depth safety-specific testing.			

21.3.8 The Software Production Standard selected by the System Design Authority to develop the software must be able to evidence the Levels of rigour tasks as equivalent to those determined by *Vol 2, Pt 1, Ch 3, 21.3 Performance requirements 21.3.7*. The justification leading to the selection of the Software Production Standard is to be documented and is to include the tasks described in *Vol 2, Pt 1, Ch 3, 21.3 Performance requirements 21.3.1* to *Vol 2, Pt 1, Ch 3, 21.3 Performance requirements 21.3.7*. The evidence supporting the case that the required Level of rigour tasks have been undertaken is to be collated by the software producer and included within the engineering

and safety justification required by *Vol 2, Pt 9, Ch 8, 5.6 Programmable electronic systems – Additional requirements for the production of software 5.6.1*. Software Conformity Assessment (SCA) may be used for this purpose.

21.3.9 Where a system or item of machinery or equipment includes more than one software module, the software safety requirements for each software module are to be specified separately.

21.3.10 Where a system or item of machinery or equipment includes more than one software module, the System Design Authority is responsible for the successful integration and performance of the software modules. In such cases, the System Design Authority is to assume those responsibilities of the software producer that relate to software integration.

Volume 2, Part 2,
Chapter 1
Reciprocating Internal Combustion Engines

■ *Section 4*
Electronically controlled engines

4.4 Software

4.4.2 Appropriate safety related processes, methods, techniques and tools are to be applied to software development and maintenance by the Enginebuilder. Selection and application of techniques and measures in accordance with Annex A of IEC 61508-3, *Functional safety of electrical/electronic/programmable electronic systems: Software requirements*, *Vol 2, Pt 1, Ch 3, 21 Software in systems, machinery and equipment* and *Vol 2, Pt 9, Ch 8, 5.6 Programmable electronic systems – Additional requirements for the production of software* or other relevant standards or codes acceptable to LR, will generally be acceptable.

Volume 2, Part 7
Chapter 1
Piping Design Requirements

■ *Section 4*
Materials

4.3 Dissimilar materials

4.3.1 Where materials vary for individual pipes and components that are joined in the presence of a conductive fluid they are either to be compatible, or electrically isolated, in order to avoid galvanic corrosion.

■ *Section 5*
Pipe joints

5.10 Other mechanical couplings

5.10.1 Pipe unions, compression couplings, or slip-on joints, as shown in *Figure 1.5.4 Examples of mechanical joints (Part 1)* and *Figure 1.5.5 Examples of mechanical joints (Part 2),* may be used if ~~Type Approved~~ type approved for the service conditions, the pipe material, and the intended application. The ~~Type Approval~~ type approval is to be based on the results of testing of the actual joints. The acceptable use for each service is indicated in *Table 1.5.3 Application of mechanical joints* and dependence upon the ~~Class~~ class of piping, with limiting pipe dimensions, working pressure and temperature, is indicated in *Table 1.5.4 Application of mechanical joints depending on class of piping.*

(Part only shown)

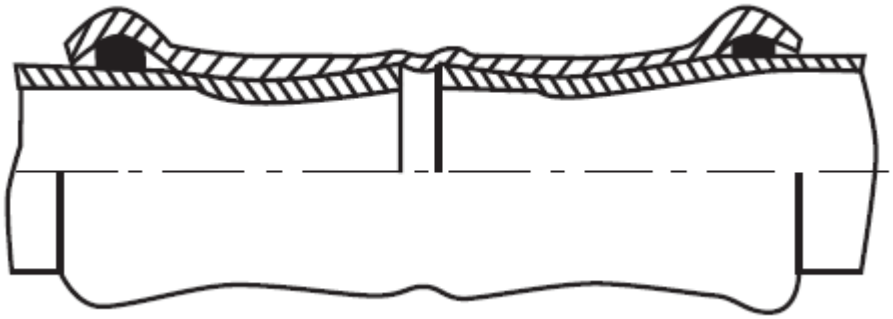
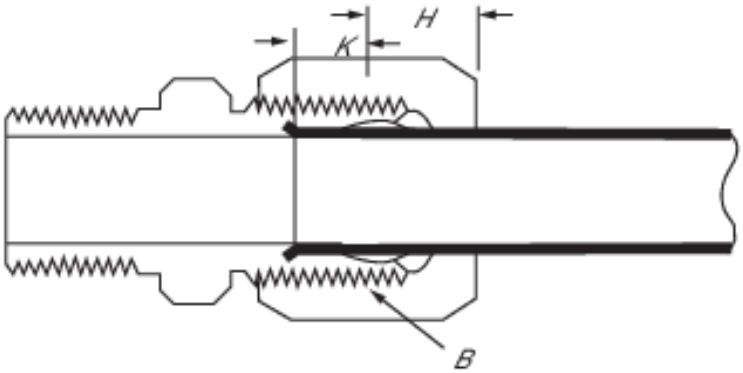
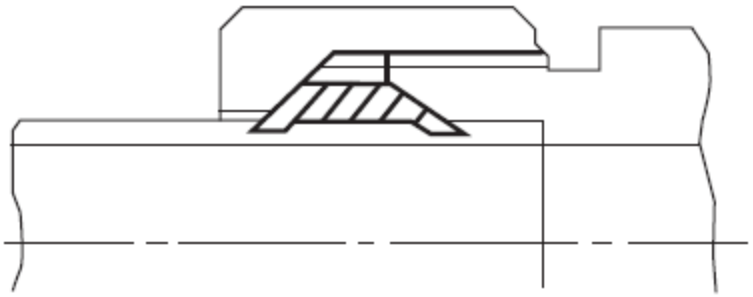
Compression couplings	
Press Type	
Typical Compression Type	
Bite Type	

Figure 1.5.4 Examples of mechanical joints (Part 1)

(Part only shown)

Table 1.5.3 Application of mechanical joints

Systems	Type of connections		
	Pipe unions	Compression coupling	Slip-on joints
Flammable fluids (Flash point <60° C)			
Aircraft and vehicle fuel oil lines *see* Notes 2 & 4	+	+	+
Vent lines *see* Notes 2 & 3	+	+	+
Flammable fluids (Flash point > 60° C)			
Aircraft and vehicle fuel oil lines *see* Notes 2 & 4	+	+	+
Ship's machinery fuel oil lines *see* Notes 2 & 3	+	+	+
Lubricating oil lines *see* Notes 2 & 3	+	+	+
Hydraulic oil *see* Notes 2 & 3	+	+	+
Thermal oil *see* Notes 2 & 3	+	+	+
Note *2*. ~~Mechanical joints that include any components which readily deteriorate in case of fire are not permitted machinery spaces of category A or accommodation spaces. Mechanical joints that include any components which readily deteriorate in~~			

~~case of fire that are of an approved fire-resistant type may be fitted in other machinery spaces provided the joints are located in easily visible and accessible positions.~~

Slip-on joints are not accepted inside machinery spaces of category A, munition stores, or accommodation spaces. Slip-on joints are accepted in other machinery and service spaces provided that the joints are located in easily visible and accessible positions.

Note *3*. Mechanical joints ~~that include any components which readily deteriorate in case of fire~~ are to be of an approved fire-resistant type~~.~~, except when they are fitted on open decks having little or no fire risk as defined in SOLAS Chapter II-2, Regulation 9.2.3.3.2.2(10).

Note *4*. Mechanical joints ~~that include any components which readily deteriorate in case of fire~~ are to be of an approved fire-resistant type ~~when fitted in pump rooms and on open decks.~~

Existing Table 1.5.4 has been deleted and replaced by the below table.

Table 1.5.4 Application of mechanical joints depending on class of piping

Types of joints	Classes of piping systems		
	Class I	Class II	Class III
Pipe unions			
Welded and brazed type	+ (OD ≤ 60,3 mm)	+ (OD ≤ 60,3 mm)	+
Compression couplings			
Swage type	-	-	+
Bite type	+ (OD ≤ 60,3 mm)	+ (OD ≤ 60,3 mm)	+
Typical compression type	+ (OD ≤ 60,3 mm)	+ (OD ≤ 60,3 mm)	+
Flared type	+ (OD ≤ 60,3 mm)	+ (OD ≤ 60,3 mm)	+
Press type	-	-	+
Slip-on joints			
Machine grooved type	+	+	+
Grip type	-	+	+
Slip type	-	+	+
KEY + Application is allowed - Application is not allowed			

5.10.12 The type or location of pipe joints may be limited by the shock policy requirements defined by the Naval Administration. The use of mechanical joints is to be considered against the shock requirements.

Volume 2, Part 7,
Chapter 3
Machinery Piping Systems

■ *Section 4*
Fuel oil pumps, pipes, fittings, tanks, etc.

4.11 Filling arrangements

4.11.2 Provision is to be made against ~~over-pressure~~ overpressure in the filling pipelines~~, and~~. Where any relief valve(s) are fitted for this purpose ~~is~~, they are to discharge to an overflow tank or other safe position.

Volume 2, Part 7,
Chapter 5
Ship Type Piping Systems

■ *Section 11*
Hydraulic power actuating systems

11.7 Pipes conveying oil

11.7.1 ~~Piping systems for flammable hydraulic fluids are to be installed to avoid fluid spray or leakage onto hot surfaces, into machinery air intakes, or onto other sources of ignition such as electrical equipment. The locations of pipe joints, valves and other potential sources of leakage are to be considered. Pipe joints are to be kept to a minimum, and where provided are to be of a type acceptable to LR. Pipes are to be led in well lit and readily visible positions.~~

The locations of pipe joints, valves, and other potential leak paths in piping systems for flammable hydraulic fluids are to be arranged so that, in the event of a leak, fluid will not come into contact with hot surfaces, machinery air intakes, electrical equipment or other sources of ignition.

11.7.2 Pipes conveying hydraulic oil under pressure are to be of seamless steel or other approved material ~~having flanged or welded joints~~, and are to be placed in sight above the platform in well lit and readily accessible parts of the machinery spaces. ~~The number of flanged joints is to be kept to a~~

Volume 2, Part 9,
Chapter 1
General Requirements for the Design and Construction of Electrotechnical Systems

■ *Section 1*
General requirements

1.3 Definitions

1.3.35 Programmable electronic system: a system based on one or more programmable electronic devices, often connected to (and including) input devices (e.g. sensors) and/or output devices/final elements (e.g. actuators), for the purposes of control, protection or monitoring.

1.3.36 An argument is used to show how the components directly underlying it relate to a claim or set of claims. *See* ISO 15026-2: *Systems and software engineering – Systems software assurance, Part 2: Assurance case.*

1.3.37 A justification gives the reason that something has been used or applied. *See* ISO 15026-2: *Systems and software engineering – Systems and software assurance, Part 2: Assurance case*.

1.3.38 Production of software: the process of interpreting requirements and realising those requirements as software modules by using suitable lifecycle steps and applying the attributes of quality, safety and other management systems. Production of software includes all lifecycle phases from requirements to support for system integration and system testing. Where iterative or cyclical lifecycles are used, the production of software includes all iterations or cycles. The production of software includes tailored lifecycle phases where existing or modified software is used.

1.3.39 Existing software: previously developed software that is to be used without modification that includes, but is not limited to, operating system, third party communications protocols, graphics, libraries and reused supplier developed code.

1.3.40 Modified software: software based upon an existing software but changed for the system being assessed. Modifications can range from setting/configuration changes to modifications that require the software to be recompiled.

1.3.41 Software Production Standard: an International or National Standard to be applied to the production of software.

1.3.42 Engineering system: any system that may be installed in a ship where such a system comprises one or more sub-systems, items of machinery or components.

1.4 Documentation required for design review

(*Part only shown*)

1.4.21 **Programmable electronic systems.** ~~(~~In addition to the documentation required by *Vol 2, Pt 9, Ch 1, 1.4 Documentation required for design review 1.4.2*~~.)~~ the following is to be submitted:

(i) Software safety requirements document, *see Vol 2, Pt 1, Ch 3, 21.3 Performance requirements 21.3.1*.
(j) The engineering and safety justification and supporting evidence, *see Vol 2, Pt 9, Ch 8, 5.6 Programmable electronic systems – Additional requirements for the production of software 5.6.3*.
(k) The certification documents for the production of software, *see Vol 2, Pt 9, Ch 8, 5.6 Programmable electronic systems – Additional requirements for the production of software 5.6.6*.
(l) The plan for the production of software, *see Vol 2, Pt 9, Ch 8, 5.6 Programmable electronic systems – Additional requirements for the production of software 5.6.7*.
(m) The registry of hardware and software, *see Vol 2, Pt 9, Ch 8, 5.6 Programmable electronic systems – Additional requirements for the production of software 5.6.21*.

1.4.29 **Configuration management plan**. Procedures for the configuration management process applied to the control, alarm and safety systems intended for the machinery or equipment as defined in *Vol 2, Pt 9, Ch 1, 1.4 Documentation required for design review 1.4.2*.

1.5 Documentation required for supporting evidence

1.5.13 For programmable electronic systems:
(a) The Systems Risk Register, where required, *see Vol 2, Pt 1, Ch 3, 21.3 Performance requirements 21.3.2*.

■ *Section 2*
System level requirements

2.8 Labels, signs and notices

2.8.5 Electrical equipment that presents an electric arc-flash hazard to personnel is to be clearly marked, *see Vol 2, Pt 9, Ch 4, 5.1 General 5.1.1*.

Volume 2, Part 9,
Chapter 3
Electrical Power Distribution and Equipment

■ *Section 5*
Switchgear and controlgear assemblies

5.14 Labels

5.14.1 The identification of individual circuits and their devices is to be made on labels of durable material. The ratings of fuses and settings of protective devices are also to be indicated. The warning of the presence of electric arc-flash hazards is also to be shown. Section and distribution boards are to be marked with the rated voltage.

Volume 2, Part 9,
Chapter 8
Programmable Electronic Systems

■ *Section 5*
Programmable electronic systems (PES)

5.1 General requirements

5.1.1 The requirements of this Section are to be complied with where control, alarm, monitoring or safety systems incorporate programmable electronic equipment. Mobility systems, ~~Ship Type~~ ship type systems and safety critical systems incorporating shared data communication links and systems which are integrated are to comply with the additional requirements of *Vol 2, Pt 9, Ch 8, 5.2 Data communication links*, *Vol 2, Pt 9, Ch 8, 5.3 Additional requirements for wireless data communication links* ~~and~~, *Vol 2, Pt 9, Ch 8, 5.4 Additional requirements for Mobility category and safety critical systems* and *Vol 2, Pt 9, Ch 8, 5.5 Additional requirements for integrated systems* as applicable.

5.2 Data communication links

5.2.12 The data communication links are to be resilient as described elsewhere in this section of the rules to the accumulation of broadcast and multicast network traffic. The audible and visual alarms required by *Vol 2, Pt 9, Ch 8, 5.2 Data communication links 5.2.6* are to be initiated in the event of such accumulations of traffic occurring and affecting normal network performance. Demonstration of this resilience is to be shown by a practical test or other acceptable means appropriate to the communication link, and documented.

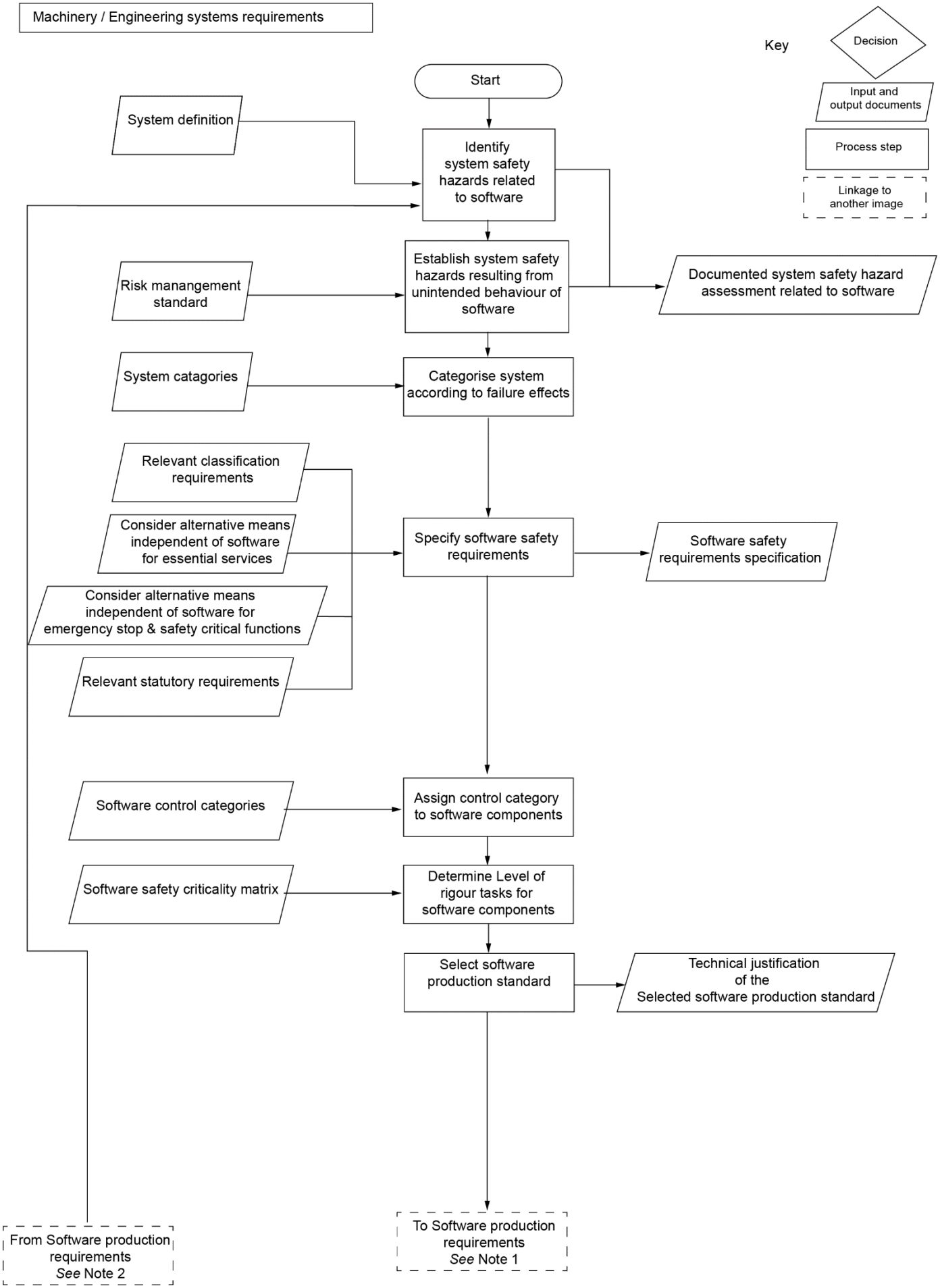
5.4 Additional requirements for Mobility category and safety critical systems

5.4.2 ~~Alternative means of safe and effective control are to be provided for Mobility category systems. Back up control systems are to be of diverse design, and are to operate independently of the main control system. Where design diversity of control system software is not practicable, the software is to satisfy the requirements of LR's *Software Conformity Assessment System – Assessment Module GEN1 (1994).*~~ Alternative means of safe and effective control are to be provided for Mobility category and safety critical systems. Back-up control systems are to be of diverse design, and are to operate independently of the main control system. The software is to comply with the requirements of *Vol 2, Pt 1, Ch 3, 21 Software in systems, machinery and equipment* and *Vol 2, Pt 9, Ch 8, 5.6 Programmable electronic systems – Additional requirements for the production of software* of these Rules. Alternatively, consideration may be given to the use of LR's *Software Conformity Assessment System – Assessment Module GEN1 (1994)* or an equivalent software assessment acceptable to LR.

5.4.8 Where it is intended that the programmable electronic system implements ~~an~~ emergency stop functions or safety critical functions, the software is to ~~satisfy the requirements of LR's *Software Conformity Assessment System – Assessment Module GEN1 (1994).*~~ comply with the requirements of *Vol 2, Pt 1, Ch 3, 21 Software in systems, machinery and equipment* and *Vol 2, Pt 9, Ch 8, 5.5 Additional requirements for integrated systems* of these Rules. Alternative proposals providing an equivalent level of system integrity will be subject to special consideration, e.g. ~~fully independent hard-wired back-up system,~~ redundancy with design diversity. ~~etc.~~ Alternatively, consideration may be given to the use of LR's *Software Conformity Assessment System – Assessment Module GEN1 (1994)* or an equivalent software assessment acceptable to LR.

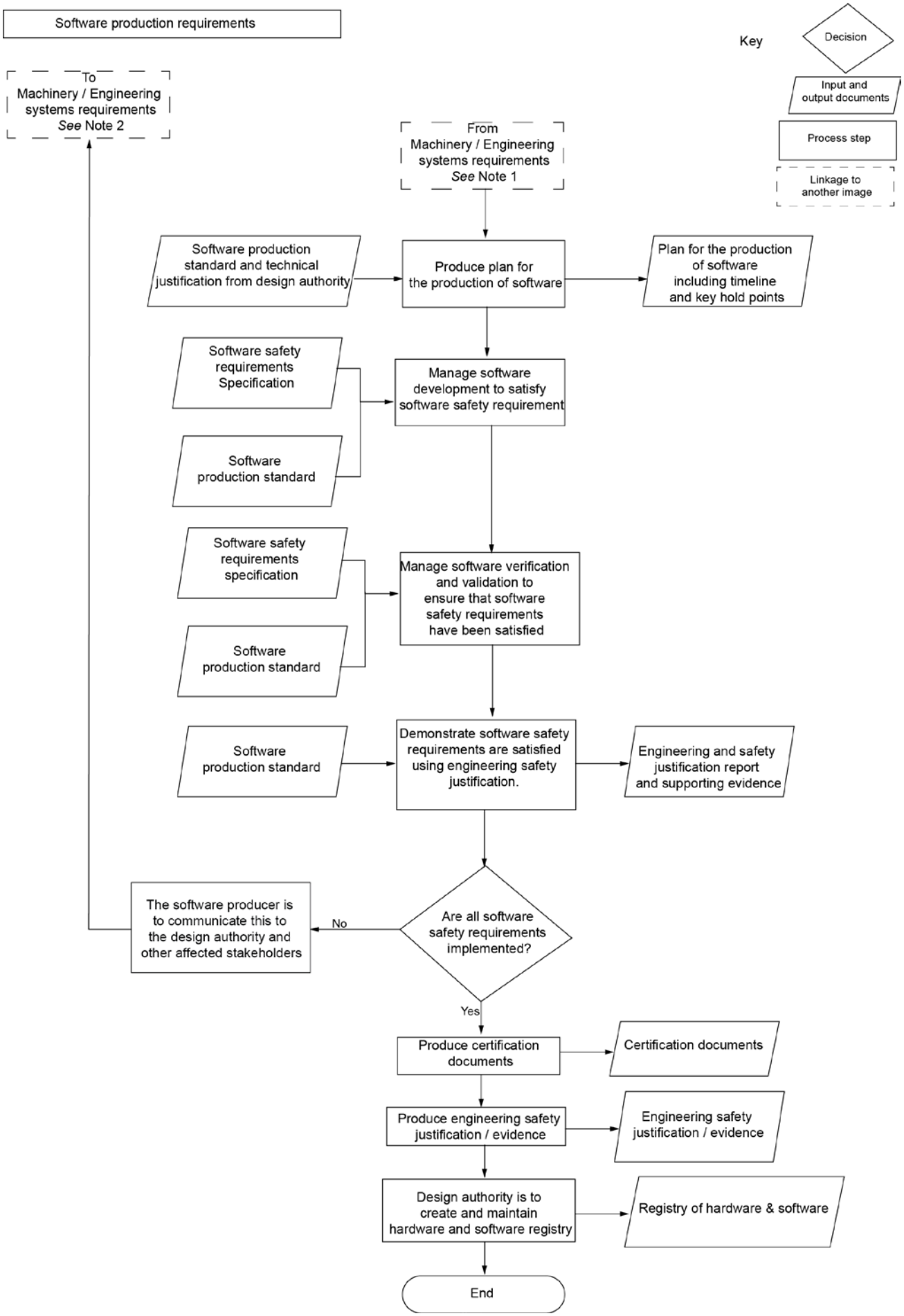
5.6 Programmable electronic systems – Additional requirements for the production of software

5.6.1 The requirements of *Vol 2, Pt 9, Ch 8, 5.6 Programmable electronic systems – Additional requirements for the production of software 5.6.1* to *Vol 2, Pt 9, Ch 8 Programmable electronic systems – Additional requirements for the production of software 5.6.24* apply to all software created for programmable electronic systems whose safety hazards have been classified within categories II, III and IV as defined by *Vol 2, Pt 1, Ch 3, 21.3 Performance requirements 21.3.5*. Alternatively, consideration may be given to the use of LR's *Software Conformity Assessment System – Assessment Module GEN1 (1994)*. *See also Vol 2, Pt 1, Ch 3, 21 Software in systems, machinery and equipment*. A diagrammatic view of the software rules process is shown in *Figure 8.5.1 Software rules process diagram – Machinery/Engineering system requirements* and *Figure 8.5.2 Software rules process diagram – Software production requirements*.



Note 1 *See* continuation in *Figure 8.5.2 Software rules process diagram – Software Production Requirements*
Note 2 Continued from *Figure 8.5.2 Software rules process diagram – Software production requirements*

Figure 8.5.1 Software rules process diagram – Machinery/Engineering system requirements



Note 1 Continued from *Figure 8.5.1 Software rules process diagram – Machinery/Engineering system requirements*
Note 2 *See* continuation in *Figure 8.5.1 Software rules process diagram – Machinery/Engineering system requirements*

Figure 8.5.2 Software rules process diagram – Software production requirements

5.6.2 The production of software is to demonstrate that the software safety requirements derived from the risk assessment required by *Vol 2, Pt 1, Ch 3, 21.3 Performance requirements 21.3.3* have been met.

5.6.3 An engineering and safety justification is to be made and documented. This is to provide compelling, comprehensible and valid arguments that the intent and requirements of the Rules have been complied with, supported by a body of evidence that provides a compelling, comprehensible and valid demonstration that the functional requirements identified in *Pt 5, Ch 1, 8.1 Goal, functional requirements and applicability 8.1.2* have been met. The engineering and safety justification is to be produced in accordance with ISO/IEC 15026-2 *Systems and software engineering – Systems and software assurance, Part 2: Assurance case* or an alternative standard acceptable to LR.

5.6.4 Where the arguments presented in the engineering and safety justification required by *Vol 2, Pt 9, Ch 8, 5.6 Programmable electronic systems – Additional requirements for the production of software 5.6.3* are not supported by evidence, it is to be shown that the identified risks associated with the engineering system are mitigated by other means; alternatively, evidence is to be submitted to LR that the residual risk is tolerable and as low as reasonably practicable.

5.6.5 Configuration management satisfying the requirements of ISO 10007 *Quality management systems – Guidelines for configuration management*, or an alternative standard acceptable to LR, is to be used during the production of software.

5.6.6 Software is to be produced using a quality management system that satisfies the requirements of ISO 9001 *Quality management systems – Requirements using the guidance of ISO 90003: Software engineering – Guidelines for the application of ISO 9001: to computer software* or an alternative to LR. Certification documents for the production of software are to be submitted to LR.

5.6.7 A plan for the production of software is to be formulated, documented and used to direct the production of software. If the plan is incorporated into another document, the strategy, and the structure of the plan, with appropriate cross-references to other documentation, are to be documented separately. The level of detail in the plan is expected to increase as the project progresses through the lifecycle phases of the production of software. The plan is to be complete with respect to each lifecycle phase before the phase is initiated.

5.6.8 The plan for the production of software is to include:

(a) all activities for the production of software, including production of the justification and supporting evidence required by *Vol 2, Pt 9, Ch 8, 5.6 Programmable electronic systems – Additional requirements for the production of software 5.6.3*;

(b) the processes, methods, techniques and tools required by the Software Production Standard and applicable to the degree of reliance placed on the software by the software safety requirements;

(c) factors which influence the introduction and mitigation of errors, such as the size, complexity and novelty of the software;

(d) any deviations, with justification, from the requirements of the Software Production Standard; and

(e) all activities for the creation of the documentation and testing of the system appropriate to the system category as defined by *Vol 2, Pt 1, Ch 3, 21.3 Performance requirements 21.3.5* and *Vol 2, Pt 1, Ch 3, 21.3 Performance requirements 21.3.7*.

5.6.9 When there are changes to the software safety requirements which affect the plan for the production of software, the plan is to be revised.

5.6.10 The production of software is to be performed in accordance with the Software Production Standard and the plan for the production of software.

5.6.11 Where software code is automatically produced by tools, the tools are to be shown to be suitable for use based on the risk that tool outputs may pose, and on any requirements of the Software Production Standard. The software producer's verification processes are to include the production of verification evidence that is to be provided to LR as part of the justification required by *Vol 2, Pt 9, Ch 8, 5.6 Programmable electronic systems – Additional requirements for the production of software 5.6.3*.

5.6.12 Where the software development includes the use of previously developed software, the plan for the development of the software is to include:

(a) defined software modification processes which are to be part of the supplier's quality management system;

(b) assessment of the impact of the modification on the previously developed software modules, which is to be used to tailor the producer of software's management systems for the specific software development modification; and

(c) integration of any additional software safety requirements identified by the risk assessment required by *Vol 2, Pt 1, Ch 3, 21.3 Performance requirements 21.3.3*, implemented through the configuration of the existing software, by providing new software to work in cooperation with the existing software, or by other means acceptable to LR.

5.6.13 During the production of software, the producer of software is to actively maintain the system safety analysis required by *Vol 2, Pt 1, Ch 3, 21.3 Performance requirements 21.3.2* to ensure that emerging properties of the software are assessed. Changes in the system safety analysis are to be documented, endorsed by the System Design Authority and mitigated through derived software safety requirements.

5.6.14 The system safety analysis documentation recording the hazards, the software safety requirements and the traceability between them is to be updated to include any additional hazards emerging from the re-evaluation analysis required by *Vol 2, Pt 9, Ch 8, 5.6 Programmable electronic systems – Additional requirements for the production of software 5.6.13*. This documentation is also to be updated when the system hazard requirements are changed, added or removed.

5.6.15 Where it is not possible to implement the original software safety requirements, or where updates are necessary as a result of additional system safety hazards, the producer of software is to communicate this to the System Design Authority and other affected stakeholders and the software safety requirements are to be re-evaluated in accordance with *Vol 2, Pt 1, Ch 3, 21.3 Performance requirements 21.3.1*.

5.6.16 Where modified software is to be used in the implementation of an engineering system, the engineering and safety justification required by *Vol 2, Pt 9, Ch 8, 5.6 Programmable electronic systems – Additional requirements for the production of software 5.6.3* is to include:

(a) why the modified and unmodified parts of the software are fit for purpose;
(b) how the system hazard requirements are satisfied by the software; and
(c) reference to evidence, both available and to be derived during the software production process, that supports the justification.

5.6.17 Where existing software is to be used in the implementation of an engineering system, the engineering and safety justification required by *Vol 2, Pt 9, Ch 8, 5.6 Programmable electronic systems – Additional requirements for the production of software 5.6.3* is to include:

(a) why the existing software is fit for purpose;
(b) how the system hazard requirements are satisfied by the existing software; and
(c) reference to evidence, both available and to be derived during the production process, that supports the justification.

5.6.18 Where software has been previously assessed and certified and the justification for the suitability of the software relies on the previous certification, the engineering and safety justification required by *Vol 2, Pt 9, Ch 8, 5.6 Programmable electronic systems – Additional requirements for the production of software 5.6.3* is to demonstrate why the existing certification is applicable to the proposed application. Evidence is to be submitted justifying the applicability of the software for the specific application, which is to include but is not to be limited to:

(a) the configuration(s) of the previously certified software;
(b) the operating scenario relevant to the previously certified software;
(c) the standard against which the previous certification was based;
(d) the applicability of any expected level of risk reduction that was previously certified;
(e) the relevance of any conditions of use placed upon the certified software;
(f) copies of the previous certification for the software;
(g) a summary of modifications and updates to the software since the issue of the previous certification; and
(h) analysis demonstrating that the degree of reliance that can be placed on the software achieving its safety requirements is less than or equal to that against which it was previously certified.

5.6.19 Where software has been previously used with development data available, and the justification for suitability of the software relies on the development data, the engineering and safety justification required by *Vol 2, Pt 9, Ch 8, 5.6 Programmable electronic systems – Additional requirements for the production of software 5.6.3* is to include, but is not to be limited to, the following evidence:

(a) The evidence supporting the argument is to be for the same software version as that of the proposed application.
(b) The producer of software is to provide access to the development data so that LR can assess the level of compliance of existing software with the rules.
(c) Where the production of software has included the use of sub-contractor(s), the producer of software is to facilitate access to data held by the sub-contractor(s).
(d) The argument is to identify any additional assurance activities that are necessary to verify that the software safety requirements have been satisfied.

5.6.20 Where software has been previously used with previous-use data available, and the justification for suitability of the software relies on the previous-use data, the engineering and safety justification required by *Vol 2, Pt 9, Ch 8, 5.6 Programmable electronic systems – Additional requirements for the production of software 5.6.3* is to include, but is not to be limited to, the following evidence:

(a) The use of the software under the same conditions as the proposed application including, but not limited to, running on the same hardware and operating system (if applicable), and having the same functional requirements.
(b) The producer of software is to provide access to the development data so that LR can assess the level of compliance of existing software with the rules.
(c) Where the software under assessment provides only part of an engineering system's software solution, the production of software is to include validation of the software module as part of the total software solution.

5.6.21 The System Design Authority is to create during the ship's design and construction phase a registry of all programmable electronic systems, logical (virtual) servers, desktops and network communication devices installed on board the ship, identifying the hardware and software installed within.

5.6.22 The System Design Authority is to maintain the registry required by *Vol 2, Pt 9, Ch 8, 5.6 Programmable electronic systems – Additional requirements for the production of software 5.6.21* and make it available to the Surveyors on request. The registry is to record all changes made to the ship's equipment during the ship's operational life, detailing as appropriate:

(a) system;
(b) vendor;
(c) system version;
(d) configuration version;
(e) date tested;
(f) test record reference;
(g) plan for production of software document reference;
(h) static network address; and
(i) records of reasons for the changes including details of any alterations to software functionality.

5.6.23 Where remote access features or facilities for enabling temporary connections with external devices are included for the programmable electronic system, the System Design Authority is to periodically review the provisions made within the hardware and software to ensure that new vulnerabilities and dependencies have not occurred or have been adequately addressed to mitigate the risk related to their possible exploitation.

5.6.24 The through-life management of the software is to be undertaken by the System Design Authority in accordance with an acceptable process for the maintenance of software. The process to be applied is to consider changes to the context of use and/or amended software in the same manner as the originally developed software by applying the plans and standards required by these Rules. Alternative processes acceptable to LR may be applied to the software maintenance activities. The System Design Authority may delegate the through-life management of software to the software producer or other organisation when undertaking software modifications. *See also Vol 2, Pt 9, Ch 1, 1.7.3 Alterations and additions*.

Volume 2, Part 12
Chapter 1
Emissions Abatement Plant for Combustion Machinery

■ *Section 10*
Storage and use of chemicals

10.2 Chemical treatment fluids used for exhaust gas cleaning systems (EGCS)

10.2.1 The aqueous solution of sodium hydroxide (NaOH) or calcium hydroxide ($Ca(OH)_2$) is commonly used as a chemical treatment fluid used for EGCS. Where other chemical treatment fluids are used, safety measures are to be taken according to the result of a risk assessment conducted to analyse the risks, in order to eliminate or mitigate the hazards to personnel on board the ship.

10.2.2 The storage tank for chemical treatment fluid is to be arranged so that any leakage will be contained and prevented from making contact with heated surfaces. All pipes and other tank penetrations are to be provided with manual closing valves attached to the tank. In cases where such valves are provided below the top of tank, they are to be provided with quick closing valves which are to be capable of being remotely operated from a position safely accessible in the event of chemical treatment fluid leakage. Tank and piping arrangements are to be approved.

10.2.3 The storage tank for chemical treatment fluid is to be protected from excessively high or low temperatures applicable to the particular concentration of chemical treatment fluids. Depending on the operational area of the ship, this may require the fitting of heating and/or cooling systems.

10.2.4 If a storage tank for chemical treatment fluid is installed in a closed compartment, then the area is to be served by an effective mechanical ventilation system of the extraction type, providing not less than 6 air changes per hour, which is independent from the ventilation system of accommodation, service spaces, or control stations. The ventilation system is to be capable of being controlled from outside the compartment. A warning notice requiring the use of such ventilation before entering the compartment shall be provided outside the compartment adjacent to each point of entry.

10.2.5 The requirements specified in *Vol 2, Pt 12, Ch 1, 10.2 Storage and use of chemicals 10.2.4* also apply to closed compartments normally entered by persons:

(a) when they are adjacent to the integral storage tank for chemical treatment fluid and there are possible leak points (e.g. manhole, fittings) from these tanks; or

(b) when the treatment fluid piping systems pass through these compartments, unless the piping system is made of steel or other equivalent material with melting point above 925°C and with fully welded joints.

10.2.6 The storage tank may be located within the engine room. In this case, a separate ventilation system is not required when a general ventilation system for the space providing not less than 6 air changes per hour is arranged so as to provide an effective movement of air in the vicinity of the storage tank and is maintained in operation continuously except when the storage tank is empty and has been thoroughly ventilated.

10.2.7 Each storage tank for chemical treatment fluid is to be provided with level monitoring arrangements and high/low level alarms. In cases where heating and/or cooling systems are provided, high and/or low temperature alarms or temperature monitoring are also to be provided.

10.2.8 The storage tanks are to have sufficient strength to withstand a pressure corresponding to the maximum height of a fluid column in the overflow pipe, with a minimum of 2,4 m above the top plate, taking into consideration the density of the treatment fluid.

10.2.9 Where chemical treatment fluid is stored in integral tanks, the following are to be considered during their design and construction:

(a) these tanks shall be designed and constructed as an integral part of the hull (e.g. double bottom, wing tanks); and

(b) these tanks shall be coated with appropriate anti-corrosion coating and are to be segregated by cofferdams or other similar spaces from accommodation, cargo spaces containing cargoes which react with chemical treatment fluid in a hazardous manner, food stores, oil tanks, lube oil tanks, aviation fuel tanks or fresh water tanks.

10.2.10 The chemical treatment fluid piping and venting systems are to be independent of other ship piping systems. The chemical treatment fluid piping systems are not to be located in accommodation, service spaces, or control stations. The vent pipes of the storage tank are to terminate in a safe location on the weather deck and the tank venting system is to be arranged to prevent entrance of water into the tank for chemical treatment fluids.

10.2.11 Storage tanks and piping systems for chemical treatment fluids which transfer undiluted chemical treatment fluids are to be of steel or other equivalent material with a melting point above 925°Celsius.

10.2.12 Storage tanks and piping systems for chemical treatment fluids are to be made with a material compatible with the chemical treatment fluids, or coated with appropriate anti-corrosion coating.

10.2.13 Regardless of design pressure and temperature, piping systems containing chemical treatment fluids are to comply with the requirements applicable to Class I piping systems.

10.2.14 The detachable connections between pipes or pipe and equipment are to be screened and fitted with drip trays to contain any spillage. The drip trays are to be fitted with drainpipes which lead to a residue tank. Tanks are to be fitted with high level alarm or are to be fitted with alarms for leakage detection. Where a tank is an integral tank, the requirements of *Vol 2, Pt 12, Ch 1, 10.2 Storage and use of chemicals 10.2.8* are to be applied.

10.2.15 For the protection of crew members, the ship is to have on board suitable personnel protective equipment consisting of protective clothing, boots, gloves and tight-fitting goggles. The amount of personnel protective equipment carried on board is to be appropriate for the number of personnel engaged in regular handling operations or that may be exposed in the event of a failure; but in no case are there to be less than two sets available on board.

10.2.16 Eyewash stations and safety showers are to be provided; the location and number is to be appropriate for the location of chemical treatment fluid systems on board. The following locations are to be provided as applicable;
(a) transfer or treatment pump locations;
(b) chemical bunkering station on deck;
(c) system connections/components that require periodic maintenance; and
(d) any part of the system where a spillage/drainage may occur.

10.2.17 Storage tanks for chemical treatment fluids are to be arranged so that they can be emptied of the fluids and ventilated by means of portable or permanent systems.

10.2.18 The holding tanks for residues generated from the exhaust gas cleaning process are to satisfy the following requirements:
(a) The tanks are to be independent from other tanks, except in cases where these tanks are also used as the overflow tanks for chemical treatment fluids storage tank.
(b) Tank capacities are to be decided in consideration of the number and type of installed exhaust gas cleaning systems as well as the maximum number of days between ports where residue can be discharged ashore. In the absence of precise data, a figure of 30 days is to be used.
(c) Where residue tanks used in closed loop chemical treatment systems are also used as the overflow tanks for chemical treatment fluid storage tanks, the requirements for storage tanks apply.

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Published by Lloyd's Register Group Limited
Registered office (Reg. no. 08126909)
71 Fenchurch Street, London, EC3M 4BS
United Kingdom

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